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(54) **Process for aerobic biotreatment**

(57) A process for biotreatment of a liquid mass, through contact with a biomass is characterized by the fact that the bioreactor in which the process is performed comprises a container holding a bed of biomass, means of supporting this bed, means of admitting the liquid mass for treatment, means of recirculating the liquid mass during treatment, means of extracting at least part of the treated liquid, and means of supplying oxygenating and emulsifying gas to the liquid mass before it comes into contact with the bacterial bed.

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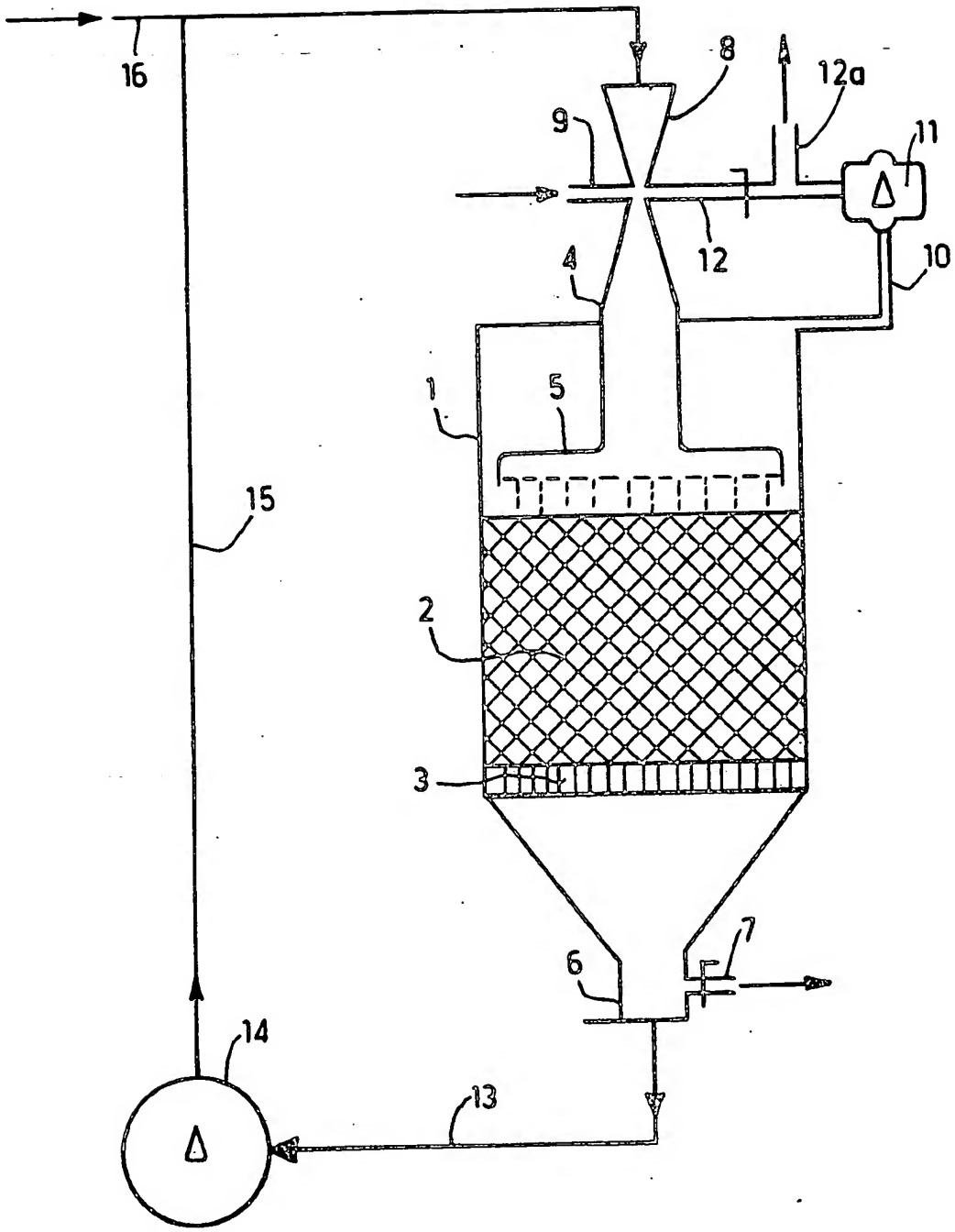
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SPECIFICATION

A process and device for aerobic biotreatment

This invention concerns a process for the biotreatment of a liquid mass, with external blending of phases.

Most such reactions require extra oxygen, and mixing must be done in such a way as to ensure that the resulting polyphase mixture is as homogeneous as possible. The extra oxygen may be supplied in various ways, such as:

—addition of gas inside the liquid mass, using mechanical or hydraulic agitation;
—effect of a jet of liquid which will draw in the surrounding gas, creating widespread agitation in the liquid mass;
—the liquid streaming over a base which acts as an air-contact surface, causing some degree of oxygenation.

However, the first two of these methods require large expenditure of mechanical energy, in order to make the mixture sufficiently homogeneous; in addition, the use of a fixed bed, which offers advantages in so many cases, is not possible.

The use of a fixed bed is possible with the third method, but it requires very cumbersome equipment, to provide an adequate interface for proper oxygenation.

One of the aims of this invention is to offer a process that will ensure satisfactory oxygenation of the liquid mass, producing proper and continuous homogeneity of the biotreatment medium, while allowing either a mobile or a fixed-bed technique to be applied, at fairly low cost and using compact equipment, and bringing about a considerable speeding-up of the biotreatment process.

This new process for the biotreatment of a liquid mass by contact with a biomass is characterized by the fact that it comprises the following stages:

a—oxygenation of the liquid mass, prior to contact with the biomass, by emulsification through the addition of oxygenating gas, in such a way that the velocity of the liquid flow sucks in the said gas;
b—fine distribution of the liquid mass;
c—contact with the biomass;
d—separation of at least part of the gas sucked in by the liquid mass;
e—recirculation of the liquid mass to stage a.

The result of this continuous oxygenation process is that the gas/liquid emulsion entering the biotreatment reactor is homogeneous enough to ensure very even contact between the liquid and the biomass bed, guaranteeing satisfactory biotreatment. Furthermore, recycling of the liquid, with the creation of a new emulsion for each cycle, helps to maintain the quality of the mixture [illegible] supply.

The oxygenating gas may be air, with added oxygen if necessary, or pure oxygen, to improve the reactivity and oxygen content of the emulsion. The volumetric ratio of gas to liquid is preferably, though not necessarily, under about 1/2. The biotreatment process may be used on any type of liquid mass, such as a solution of a convertible product or industrial waste, waste water, or any other substances suitable for conversion, processing or destruction.

The biological reactor in which this new process is performed comprises:

a—a container forming a biotreatment reactor for a biomass;
b—means of admitting the liquid mass for treatment into the upper part of the container;
c—means of adding an oxygenating gas to the liquid mass, in such a way that the velocity of the liquid sucks in the gas;
d—means of fine distribution of the liquid mass;
e—means of separation of at least part of the gas sucked in by the liquid mass;
f—means of recirculating the liquid mass back to the top of the container.

The reactor preferably contains means of supporting the biomass in the form of a fixed bed.

One important feature of the invention is that the means of injecting oxygenating gas and emulsion consist of an emulsification venturi, into the neck of which the oxygenating gas is admitted, and which is designed in such a way that the velocity of the liquid passing through the neck sucks in gas, thereby forming a very fine emulsion in the divergent portion of the venturi.

The homogeneity of the liquid streaming over the biomass bed is improved by distributing the gas-liquid emulsion finely over or inside this bed, using a device comprising for example a series of perforations, through which the emulsion sprays over the bed.

Repeated oxygenation and recirculation of the reaction liquid mean that it is possible to use fixed fittings for the biomass bed inside the reactor. For instance, these fixtures may consist of rot-proof porous or plastic material, providing a large contact surface area, and holding the biomass in a concentrated form.

Naturally, such fittings can be removed, and the biomass recirculated, in which case it is no longer in the form of a fixed bed, and is no longer necessarily fixed to a base.

On leaving the reactor, the emulsion passes through a fine grid, centrifugal separator or similar device, to remove all or part of the unused gas in the liquid, in order to make recirculation easier, helping to retain biomass supports.

In order to reduce oxygen consumption, the container may comprise a pipe to collect gas the emulsion, and means of

conveying and reinjecting it into the liquid mass above the biomass bed.

The fermentation device described briefly above can function with low rates of recycling, to perform reactions that require little oxygen, at very limited energy cost, or with high rates of recycling, for reactions requiring large amounts of oxygen; in either case it ensures perfect homogeneity for the emulsion of oxygenating gas and liquid.

The gas-liquid contact surface is created in emulsion form outside the reactor, and contact between oxygen and material for treatment on the fixed bed takes place inside the reactor with the emulsion, making full use of the activity of the immobilized micro-organisms.

This type of apparatus can be used for fixed-bed fermentations,without the need for large volumes.

Other aims and advantages of the invention will become clear from the following description of one possible embodiment, and with reference to the accompanying figure, providing a diagrammatical view of a device for this new process.

The bioreactor comprises a biotreatment container 1, containing a bed of biomass 2, consisting of supporting fixtures with extensive surface area, such as rings or fittings of other shapes, made from rot-proof ans corrosion-proof material. The emulsified, oxygenated liquid passes through this container, streaming over the biomass, which is supported beneath by a device 3, this may be used to break up any residual emulsion as it leaves the biomass. At the top of the container 1 there is a passage 4, through which the emulsion is admitted, and a perforated distributor 5 below it, to spread the emulsion over the top surface of the biomass bed 2 in the form of a fine spray. The bottom of the container narrows in a funnel shape, leading to a collector pipe 6, out of which leads an extraction pipe 7.

The inlet passage 4 is connected to a convergent-divergent venturi 8. A pipe 9 leading into the neck of this venturi is used to inject an oxygenating and emulsifying gas, such as air, with added oxygen if necessary, or pure oxygen, possibly with other gases to intensify, stabilize, or if necessary slow down and even halt the reaction.

Gas released over the biomass bed, and any gas produced during fermentation, are collected at the top of the container 1, through a pipe 10 and reinjected into the neck of the venturi 8, by a pump 11, through a reinjection pipe 2, or else totally or partly removed through an extractor pipe 12a.

Part of the liquid in the collector pipe 6 is conveyed through a pipe 13 to a circulating pump 14, which delivers it to the venturi inlet, through a pipe 15, connected to a new liquid injection pipe 16.

This bioreactor functions in the following way.

The liquid to be treated, such as products for conversion, or waste matter or water to be processed or destroyed, is admitted into the container 1 through the injection pipe 16, and at the inlet to the venturi 8 it mixes with liquid recirculated by the pump 14. The oxygenation gas entering the venturi neck through the injection pipe 9, and possibly the reinjection pipe 12, is sucked in by the liquid, inside which a vacuum is created at the venturi neck, where its static pressure is converted into dynamic pressure. This process results in a very fine emulsion. In one embodiment of the invention, the ratio of gas to liquid is under 0.5.

This fine emulsion is distributed by the inlet passage 4 and distributor 5 over the top of the biomass bed 2, flowing slowly over the extensive contact surface area of the bed, resupplying it with oxygen.

By gravity, the liquid eventually reaches the base of the bed 2, and passes through the device 3, which reduces the gas-liquid emulsion, releasing the liquid, accompanied by fermentation products. It collects in the pipe 6, being removed by the pipe 7 and partly recirculated by the pump 14. Adjustable amounts of gas and liquid are extracted through pipes 12a, 7 and 13, depending on the progress of the biotreatment on the bed 2.

This new equipment has proved equally efective for the complete destruction of organic pollution matter in waste water, for example from the agro-food industry, for bioconversion of various substrates, such as alcohol-acid conversion, and for conversion of these polluting substances into single-cell proteins without the use of a fixed bed.

Naturally, this invention is in no way confined to the embodiments described and illustrated here: many variant forms are possible for someone skilled in the art, depending on the applications involved, and without any departure from the spirit of the invention.

For instance, biotreatment may be initiated or stabilized by the use of a closed circuit, without the addition of external fluid, or by successive closed biotreatment cycles. It would even be possible to reverse the direction of circulation periodically, for example to regenerate the lower part of the biomass and clear out the device 3. Similarly, the flow-rates of gas and liquid can be adjusted by instruments measuring the activity of the bacterial bed or the progress of biotreatment. A heating and/or cooling exchanger may be fitted to recirculating pipes 13 and/or 10–12, and/or supply pipe 16 and/or extraction pipes 7 and/or 12a. Similarly, the reaction may take place on a bacterial bed that is not immobilized, the oxygen supply still being provided by an emulsion prepared outside the

This new process can also be performed on a circulating biomass bed, in which case the reactor may comprise means of recirculating the bed.

In another embodiment of the invention, the grid 3 immobilizing the biomass bed is not included, so that the reactor becomes a fermenter or purifier, without requiring any change in the oxygenating system. In this case, the recirculation pump 14 recirculates the biomass simultaneously with the liquid mass. The result is a mobile-bed system, in which case it is not necessary for the biomass to be fixed to a base. This capacity to function equally well as a fixed-bed or as a mobile-bed system is another advantage of the present process and device.

The embodiment in which the gas-liquid emulsion is distributed within the bacterial bed, and which is not illustrated would involve the use of a sphere-shaped distributor 5, for example, with a perforated surface. This sphere, connected to the inlet passage 4 by some appropriate means, is situated within the bacterial bed 2.

CLAIMS

1. A process for the biotreatment of a liquid mass by means of contact with a biomass, comprising the following stages:
a—oxygenation of the liquid mass, prior to contact with the biomass, by emulsification through the addition of oxygenating gas, in such a way that the velocity of the liquid flow sucks in the said gas;
b—fine distribution of the liquid mass;
c—contact with the biomass;
d—separation of at least part of the gas sucked in by the liquid mass;
e—recirculation of the liquid mass to stage a.

2. A process as defined in claim 1, in which the biomass is supported on fittings forming a fixed bed, and the means of separating at least part of the gas sucked in by the liquid mass also supported on this fixed bed.

3. A process as defined in claim 1 or 2, in which the liquid mass is distributed by spraying finely over the biomass.

4. A process as defined in claim 2, in which the liquid mass is distributed inside the biomass bed.

5. A process as defined in any one or other of claims 1 to 4, in which the biomass consists of proliferating or non-proliferating microorganisms, or sub-cellular fractions of such micro-organisms, or enzymes.

6. A process as defined in any one or other of claims 1 to 5, in which the oxygenating gas is air, possibly with added oxygen.

7. A process as defined in any one or other of claims 1 to 5, in which the oxygenating gas is pure oxygen.

8. A process as defined in any one or other of claims 1 to 7, in which the liquid mass is a solution or of industrial waste.

9. A process as defined in any one or other of claims 1 to 7, in which the liquid mass consists of waste water, or substrate for biotreatment.

10. A device for the performance of a process as defined in any one one or other of claims 1 to 9, comprising:
a—a container forming a biotreatment reactor for a biomass;
b—means of admitting the liquid mass for treatment into the upper part of the container;
c—means of adding oxygenating gas to the liquid means, in such a way that the velocity of the liquid sucks in the gas;
d—means of distribution of the liquid means;
e—means of separating at least one part of the gas sucked in by the liquid mass;
f—means of recirculating the liquid mass back to the top of the container.

11. A device as defined in claim 10, in which the container comprises means of holding the biomass, such as a fitting forming a fixed bed, supported by the gas-separating device.

12. A device as defined in claim 10 or 11, in which the means of adding oxygenating and emulsifying gas consist of an emulsion venturi, into the neck of which the gas is sucked by the liquid.

13. A device as defined in claim 12, in which the emulsion venturi is designed in such a way that the velocity of the liquid at the neck sucks in gas, creating a very fine emulsion in the divergent portion of the venturi.

14. A device as defined in any one or other of claims 10 to 13, in which the gas-admission system is located outside the container in which the fixed bed of biomass may be placed.

15. A device as defined in any one or other of claims 10 to 14, in which the gas-liquid emulsion is distributed over the biomass bed by means that spray it finely, preferably consisting of a series of perforations.

16. A device as defined in any one or other of claims 10 to 14, in which the gas-liquid emulsion is distributed inside the biomass bed by means of a fine distribution system.

17. A device as defined in any one or other of claims 10 to 16, in which the means of supporting the biomass bed are fixed inside the container, and consist of fixtures, preferably of rotproof plastic or porous material, to hold the biomass in a fixed position, providing an extensive contact surface area.

18. A device as defined in claim 17, in which the fixtures holding the biomass bed are supported by means also capable of breaking up the gas-liquid emulsion, in order to make extraction and recirculation of the liquid easier, and improve conditions of transfer.

ce as defined in claim 17, in

which the means of support consist of a fine grid, centrifugal or similar separator, capable of breaking up the gas-liquid emulsion, totally or partly, in order to make recirculation of the liquid easier.

20. A device as defined in any one or other of claims 10 to 19, in which the container holding the biomass bed comprises a pipe to collect gas released by the emulsion, and means of conveying and reinjecting this oxygenating gas into the liquid mass above the biomass bed.

21. A process for the biotreatment of a liquid mass, substantially as hereinbefore described with reference to the foregoing drawing.

22. A device for performing biotreatment of a liquid mass, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

23. Any novel feature or combination of features described herein.

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